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Multi-Product Firms, Product Scope, and the Policy of Export Tax Rebate

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Abstract

Following [Nocke and Yeaple \(2012\)](#), we develop a model to explain how firms allocate their organizational capital to different products. Using the Chinese export and tax rebate data, we find that the reduction of export tax rebate causes contraction of product scope, and the less competitive products are more likely to be dropped.

Keywords:

Heterogenous Firms, Multi-product Firms, Product Scope, Export Tax Rebate

JEL Classification: D22, F10, F14, L10

1. Introduction

Recent development in trade literature has shifted the focus to the multi-product firms' performance in markets ([Bernard et al., 2010, 2011](#); [Eckel and Neary, 2006](#); [Nocke and Yeaple, 2008, 2012](#); [Manova and Zhang, 2012](#)). Multi-product firms produce goods varying not only in quality, but also with different factor intensity ([Song and Zhu, 2011](#)). [Bernard et al. \(2010\)](#) find that the product factor intensities vary substantially for a multi-product firm and trade liberalization leads firms to drop their least successful products. Using Belgian manufacturing firm-level data, [Fuss and Zhu \(2012\)](#) show that about 30% of manufacturing firms produce goods in more than one 4-digit

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NACE code industries, and trade liberalization results in faster TFP growth in comparative-advantage industries.

Our model illustrates the way how multi-product firms manage their product scope in response to the reduction of export tax rebate (ETR). In particular, firms allocate their organizational capital among different products. The product-level organizational capital, cost parameter, along with firm-level efficiency jointly determines the firm-product-level profit. The model suggests that the reduction of ETR causes product scope contraction, and the product of higher cost is more likely to be dropped. Our result is supported by the Chinese export data. Our result makes an additional contribution to the literature on multi-product firms and product-level heterogeneity in factor intensity¹. To the best of our knowledge, similar studies are scanty in the literature. Two related studies are [Nocke and Yeaple \(2012\)](#) and [Manova and Zhang \(2012\)](#), who investigate the product scope adjustment of multi-product firms. However, the former neglects the heterogeneity in factor intensity across products, and the data limitation prevents them from further exploring the extensive margin changes; the latter introduces quality differentiation across products, but no explanations on why firms differentiate their product quality ex ante and drop their low quality product ex post are provided.

Our findings shed light on the determinant of extensive margin adjustment of export firms. It is found that the reduction of ETR forces export firms to drop their less competitive products. The extensive margin changes further increase the aggregate TFP of export firms.

2. The Model

Each firm decides its product scope, price, and export status. Following [Nocke and Yeaple \(2012\)](#), we assume that firms are heterogeneous in organizational capital and organizational efficiency. The production of each product requires labor, intermediate input and organizational capital. The more organizational capital is used in the production, the lower the marginal cost is, and the organizational efficiency determines the effectiveness of the organizational capital in reducing the marginal cost. The production of each

¹We interpret product-level heterogeneity of factor intensity as product-level difference in comparative advantage.

product needs a fixed cost in each period. A representative firm's production function for product ω is

$$Q = \theta_\omega l^{\alpha_\omega} m^{1-\alpha_\omega} \quad (1)$$

where $\theta_\omega = k_\omega^\theta$ is the productivity of product ω , which is determined by the organizational capital k_ω allocating to product ω , the firm specific organizational efficiency θ . The total organizational capital is fixed at K_θ ($\sum_\omega k_\omega = K_\theta$) for the firm. l and m are the labor and intermediate inputs, respectively. The parameter α_ω is labor share. We assume that producing product ω requires at least one unit of organizational capital. The marginal cost of product ω is

$$c(k_\omega, \theta, z_\omega) = \begin{cases} z_\omega k_\omega^{-\theta}, & \text{if } k_\omega \geq 1; \\ \infty, & \text{if otherwise.} \end{cases} \quad (2)$$

$$z_\omega = w_m^{1-\alpha_\omega} w_l^{\alpha_\omega} \left[\left(\frac{1-\alpha_\omega}{\alpha_\omega} \right)^{\alpha_\omega} + \left(\frac{\alpha_\omega}{1-\alpha_\omega} \right)^{1-\alpha_\omega} \right] \quad (3)$$

where w_l and w_m are prices for labor and intermediate input, respectively. z_ω is called cost parameter.

The consumers in the domestic and foreign markets have identical preference over varieties and take the CES form:

$$U = \left[\int_\Omega x_\omega^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}} \quad (4)$$

where x_ω is the consumption of product ω , and $\sigma > 1$ is the substitution elasticity between products. We assume that the intermediate input can freely flow between the domestic and foreign markets, and so the two markets have the same intermediate price level. L and L^* are populations in the domestic and foreign markets, respectively. $w_l L$ and $w_l^* L^*$ are the corresponding aggregate incomes. The domestic and foreign demand functions generated by the preference are $x_\omega = A p(\omega)^{-\sigma}$ and $x_\omega^* = A^* p^*(\omega)^{-\sigma}$, where $p(\omega)$ (or $p^*(\omega)$) is the price in the domestic (or foreign) market, and A (or A^*) is the corresponding residual demand in the domestic (or foreign) market which

can be written as ²

$$A = \frac{(1 - \beta)w_l L}{M \left[\int p(K_\theta, \theta, z)^{-(\sigma-1)} dG(K_\theta, \theta, z) \right]}$$

$$A^* = \frac{(1 - \beta^*)w_l^* L^*}{M^* \left[\int p^*(K_\theta, \theta, z)^{-(\sigma-1)} dG(K_\theta, \theta, z) \right]}$$

The parameter β (β^*) is the firm-level exit probability in the domestic (or foreign) market, and M (or M^*) measures the number of potential entrants in the domestic (or foreign) market. The equilibrium is solved by backward induction.

The third stage: The representative firm chooses optimal prices in the domestic and foreign markets. That is, $p(k_\omega, \theta, z_\omega) = \frac{\sigma}{\sigma-1} c(k_\omega, \theta, z_\omega)$, $p^*(k_\omega, \theta, z_\omega) = \frac{\sigma}{\sigma-1} c^*(k_\omega, \theta, z_\omega)$ and $c^*(k_\omega, \theta, z_\omega) = \tau c(k_\omega, \theta, z_\omega)$ where τ is per unit iceberg trade cost, $\tau > 1$.

The second stage: The firm decides the product scope. For ω to be produced, two conditions must be satisfied. First, the profit obtained from ω must be non-negative. The profit is given by

$$\pi(k_\omega, \theta, z_\omega) = \frac{1}{\sigma-1} \left(\frac{\sigma}{\sigma-1} \right)^{-\sigma} \tilde{A} (z_\omega k_\omega^{-\theta})^{1-\sigma} - f_\omega \quad (5)$$

where \tilde{A} is the aggregate residual demand in the domestic and foreign markets, and f_ω is the fixed production cost. Second, the marginal profits of all products ω must be identical.³ That is, $\frac{\partial \pi_i}{\partial k_i} = \frac{\partial \pi_j}{\partial k_j}$. Identical export decision among all products⁴ implies

$$\frac{k_i}{k_j} = \left(\frac{\tilde{z}_j}{\tilde{z}_i} \right)^{\frac{1}{(\sigma-1)\theta-1}}$$

where $\tilde{z}_i = z_i^{1-\sigma}$. Therefore, a firm will allocate more organizational capital to products of lower cost parameter z .

² $M/(1-\beta)$ (or $M/(1-\beta^*)$) is the mass of active firms in the domestic (or foreign) market. $\int p(k, \theta, z)^{-(\sigma-1)} dG(K_\theta, \theta, z)$ (or $\int p^*(k, \theta, z)^{-(\sigma-1)} dG(K_\theta, \theta, z)$) is the price index in the domestic (or foreign) market.

³ Our analysis is for firms with $\theta < \frac{1}{(\sigma-1)}$, which guarantees the concavity of the organizational capital. For firms with $\theta > \frac{1}{(\sigma-1)}$, it will only produce one product with the lowest cost parameter z .

⁴ The entry cost is in the firm-level.

Lemma 1. Suppose $z_1 < z_2 < \dots < z_N$ and N is the integrity part of K_θ . The optimal product scope N^* is given by

$$N^* = \sup_{n \in \{1, 2, \dots, N\}} \{n : \tilde{z}_n k_n^{[(\sigma-1)\theta-1]} \geq \tilde{z}_1 k_1^{[(\sigma-1)\theta-1]}\} \quad (6)$$

where

$$k_n = \frac{K_\theta}{Z} \left(\frac{\tilde{z}_1}{\tilde{z}_n} \right)^{\frac{1}{[(\sigma-1)\theta-1]}}, \quad Z = \sum_{n=1}^{N^*} \left(\frac{\tilde{z}_1}{\tilde{z}_n} \right)^{\frac{1}{[(\sigma-1)\theta-1]}}$$

Lemma 2. If the mean of the fixed cost f_ω is the same for all $\omega \in \Omega$, then the product-level profit is negatively correlated to its cost parameter.

The first stage: The Firm makes the market entry decision. The free entry conditions are that the total discounted profit is equal to the fixed entry cost, i.e., $\int_{\Theta} V(K_\theta, \theta, z) dG(K_\theta, \theta, z) = F_e$ and $\int_{\Theta} V^*(K_\theta, \theta, z) dG(K_\theta, \theta, z) = F_e^*$ for domestic and foreign markets, respectively.⁵

Lemma 3. N^* is increasing in the total organizational capital stock K .

It implies that firms with more capital choose larger product scope.

Proposition 1. When τ rises, firms contract their product scope and hence the products of higher cost parameter are more likely to be dropped.

3. The Impact of Export Tax Rebate on Firm's Product Scope

The reduction of ETR is similar to an increase in trade cost,⁶ which reduces the export profit of each product, and further reduce firm-level total profit in foreign market. By proposition 1, the reduction of ETR causes firm-level product scope contraction and dropping of high cost products.

⁵ $V(K_\theta, \theta, z) = \sum_{\omega \in \Omega} \frac{\frac{1}{\sigma-1} A(z_\omega k_\omega^{-\theta})^{(1-\sigma)} - f_\omega}{1-\beta}$. $V^*(K_\theta, \theta, z) = \sum_{\omega \in \Omega} \frac{\frac{1}{\sigma-1} A^*(z_\omega k_\omega^{-\theta})^{(1-\sigma)}}{1-\beta^*}$.

⁶The reduction of ETR, hence the increase in trade cost, is unbalanced among different products

Table 1: The Percentile of Firms Exporting Different Number of Products

Number of Products	Percentile of Ordinary Trade	Percentile of Full Sample
1	32.7%	32.9%
2	16.9%	17.1%
3	10.4%	10.6%
4	7.0%	7.2%
> 4	32.9%	32.1%

3.1. Data

We collect the data of ETR rate for the comprehensive Chinese export sectors in 2003 and 2004, and carefully merge the data with Chinese Customs data using the 8-digit HS code. In 2004, the ETR reform reduces the average ETR rate by about 30% to adjust the structure of export and the rebate payment default.

Table 1 shows that about 70% of firms⁷ export more than one product at 4-digit HS code level in the same year.

3.2. Empirical Evidence

The following regression is used to test the prediction of scope contraction in response to the reduction of ETR.

$$num_diff_i = \beta_0 + \beta_1 tax_diff_i + \beta_2 os_d_i + \varepsilon_i \quad (7)$$

where num_diff_i is the difference of firm i 's product scope between 2003 and 2004, tax_diff_i is the difference of firm i 's revenue-weighted ETR,⁸ and os_d_i is the ownership dummy controlling for the effect of firm-type. The results are in Table 2.

The results after controlling for firm-type imply that firms experiencing larger ETR reduction cut more products.

Next, we estimate a Probit regression to see if higher cost products are more likely to be dropped.

$$\Pr(exit_{ij} = 1) = \Pr(\beta_1 rca_j + \beta_2 tax_diff_i + \beta_3 os_d_i + \varepsilon_{ij} > 0) \quad (8)$$

⁷In the following analysis we only keep the export firms engaging in the ordinary trade in our sample as the firms involving in processing trade might react differently when facing the export rebate changes.

⁸We use the figures in 2004 subtracting the figures in 2003, e.g. $num_diff_i = num_{2004} - num_{2003}$ and $tax_diff_i = tax_diff_i^{2004} - tax_diff_i^{2003}$

Table 2: The Extensive Margin

<i>num_diff</i>	Coef	Coef
<i>tax_diff</i>	0.24 (0.034)	-0.11 (0.033)
<i>Cons</i>	-2.39 (0.048)	0.16 (6.09)
Control for Ownership	No	Yes

Table 3: The Intensive Margin

<i>exit</i>	Coef	Coef
<i>rca</i>	-0.19 (0.05)	-0.23 (0.05)
<i>tax_diff</i>	-0.29 (0.66)	-0.34 (0.65)
<i>Cons</i>	-2.49 (0.07)	-0.89 (0.57)
Control for Ownership	No	Yes

where $exit_{ij}$ is a dummy variable which takes value 1 if the j th product of firm i is dropped, otherwise takes value 0, rca_j is the relative comparative advantage index of Chinese firms⁹ which is a proxy for cost parameters z , and tax_diff_i and os_d_i are the difference of firm i 's revenue-weighted ETR and the ownership dummies, respectively.

Table 3 reports the results of the Probit regression. It indicates that higher cost products are more likely to be dropped in response to the reduction of ETR. The pattern is line with the model prediction.

4. Conclusion

In this paper we extend the seminal work of [Nocke and Yeaple \(2012\)](#) and develop a model to explain how multi-product firms contract their product scope in response to a trade cost increment. When the trade cost increases, firms will drop their less competitive products to release organizational, and reallocate the organizational capital to other products. Our theory

⁹This index is given by $rca_j = (\frac{x_{ij}}{x_i})/(\frac{x_j}{x})$ where x_{ij} denotes the export product j by country i , x_i denotes the total export of country i , x_j is the total worldwide export of product j , and x represent the total worldwide export. We assume that China is intensive in labor, and the foreign country is intensive in capital. As such the wage is relatively lower in China ($w_l < w_m$) than that in the foreign country ($w_l^* > w_m^* = w_m$). The sectors with larger labor share, α , are relatively more competitive (lower z) than those with lower labor share (higher z).

is supported by the empirical evidence from China. An important policy implication of the results is that the reduction of the ETR makes export firms drop their less competitive products, which increases firm-level TFP.

5. Appendix (For Reviewers)

Proof of (2). A firm minimizes $w_l l + w_m m$ subject to the constraint $\theta_\omega l^{\alpha_\omega} m^{1-\alpha_\omega} = 1$. The first-order conditions imply $\frac{m}{l} = \frac{w_l}{w_m} \frac{1-\alpha_\omega}{\alpha_\omega}$. The optimal labor and intermediate inputs are

$$m = \left(\frac{w_l}{w_m} \frac{1-\alpha_\omega}{\alpha_\omega} \right)^{\alpha_\omega} \frac{1}{\theta_\omega},$$

$$l = \left(\frac{w_m}{w_l} \frac{\alpha_\omega}{1-\alpha_\omega} \right)^{1-\alpha_\omega} \frac{1}{\theta_\omega}.$$

Therefore the minimized cost is $c = z_\omega k_\omega^{-\theta}$ where z_ω is defined by (3). \square

Proof of (5). The profit from product ω is

$$\begin{aligned} \pi(k_\omega, \theta, z_\omega) &= [p(k_\omega, \theta, z_\omega) - c(k_\omega, \theta, z_\omega)] A p(k_\omega, \theta, z_\omega)^{-\sigma} \\ &\quad + [p^*(k_\omega, \theta, z_\omega) - c^*(k_\omega, \theta, z_\omega)] A^* p^*(k_\omega, \theta, z_\omega)^{-\sigma} \\ &\quad - f_\omega \\ &= \frac{1}{\sigma-1} \left(\frac{\sigma}{\sigma-1} \right)^{-\sigma} \tilde{A} (z_\omega k_\omega^{-\theta})^{(1-\sigma)} - f_\omega \end{aligned}$$

where $\tilde{A} = (A + \delta_\omega \tau^{1-\sigma} A^*)$. If the firm exports product ω , $\delta_\omega = 1$. Otherwise $\delta_\omega = 0$. As the profits in the domestic and foreign markets are strictly positive after paying the fixed production cost f_ω , the firm will choose to export all products or choose not to export any product. The decision is determined by the entry cost in the foreign market. \square

Proof of Lemma 1. $\sum k_\omega = K_\theta$ implies

$$k_1 + \left(\frac{\tilde{z}_1}{\tilde{z}_2} \right)^{\frac{1}{(\sigma-1)\theta-1}} k_1 + \dots + \left(\frac{\tilde{z}_1}{\tilde{z}_{N^*}} \right)^{\frac{1}{(\sigma-1)\theta-1}} k_1 = K_\theta$$

Obviously

$$k_1 = \frac{K_\theta}{Z}, \quad k_n = \frac{K_\theta}{Z} \left(\frac{\tilde{z}_1}{\tilde{z}_n} \right)^{\frac{1}{(\sigma-1)\theta-1}} \quad (\text{A1})$$

for $n = 2, \dots, N^*$, where $Z = \sum_{n=1}^{N^*} \left(\frac{\tilde{z}_1}{\tilde{z}_n} \right)^{\frac{1}{(\sigma-1)\theta-1}}$.

When we rank the cost parameter in the form of $z_1 < \dots < z_N$, the N^* th product is of the highest cost parameter among all produced products. The marginal profits obtained from N^* th product must be equal to the marginal profits obtained from any other products. Therefore, N^* must satisfy (6). \square

Proof of Lemma 2. For convenience, we denote the product-level profit $\pi(k_\omega, \theta, k_\omega)$ by π_ω for $\omega \in \Omega$. The expected profit of products $i, j \in \Omega$ are

$$\begin{aligned} E\pi_i &= \frac{1}{\sigma-1} \left(\frac{\sigma}{\sigma-1} \right)^{-\sigma} \tilde{A}(z_i k_i^{-\theta})^{(1-\sigma)} - f, \\ E\pi_j &= \frac{1}{\sigma-1} \left(\frac{\sigma}{\sigma-1} \right)^{-\sigma} \tilde{A}(z_j k_j^{-\theta})^{(1-\sigma)} - f, \end{aligned}$$

which implies

$$\frac{E\pi_i + f}{E\pi_j + f} = \frac{(z_i k_i^{-\theta})^{1-\sigma}}{(z_j k_j^{-\theta})^{1-\sigma}} = \left(\frac{z_j}{z_i} \right)^{\frac{1-\sigma}{(\sigma-1)\theta-1}}$$

under (A1). If $z_i < z_j$, then $\frac{E\pi_i + f}{E\pi_j + f} > 1$ which implies $E\pi_i > E\pi_j$. \square

Proof of Lemma 3. Suppose N^* is decreasing in K_θ . When K_θ increases and N^* decreases, (A1) implies k_1 will increase to k'_1 . Then

$$\tilde{z}_{N^*} k_{N^*}^{(\sigma-1)\theta-1} \geq \tilde{z}_1 k_1^{(\sigma-1)\theta-1} > \tilde{z}_1 k'_1{}^{(\sigma-1)\theta-1}$$

The inequality implies that product N^* should be produced to maximize the firm's profit. It means N^* does not fall when the K_θ increases. By contradiction, N^* is increasing in K_θ . \square

Proof of Proposition 1. Let $\Gamma_\omega \triangleq \frac{1}{\sigma-1} \left(\frac{\sigma}{\sigma-1} \right)^{-\sigma} (z_\omega k_\omega^{-\theta})^{(1-\sigma)}$. Then $E\pi_\omega = \Gamma_\omega (A + \tau^{1-\sigma} A^*) - f$. It follows that $\frac{\partial E\pi_\omega}{\partial \tau} = -(\sigma-1)\Gamma_\omega \tau^{-\sigma} A^* < 0$. Given τ , for any $i, j \in \Omega$, suppose $z_i < z_j$. Lemma 2 implies $E\pi_i > E\pi_j$ or $\Gamma_i > \Gamma_j$. Let τ^* be defined by $E\pi_j = 0$ or equivalently $\Gamma_j (A + \tau^{*1-\sigma} A^*) - f = 0$. It implies $A + \tau^{*1-\sigma} A^* = \frac{f}{\Gamma_j}$. Conditional on $\tau = \tau^*$, the expected profit of product i is $E\pi_i = \Gamma_i \frac{f}{\Gamma_j} - f > 0$ because of $\Gamma_i > \Gamma_j$.

Let τ rise from $\tau_0 < \tau^*$. Initially $E\pi_i > 0$ and $E\pi_j > 0$, which imply both of them are kept on average. When τ rises to τ^* , $E\pi_i > 0$ and $E\pi_j = 0$. It follows, on average, that the product j will be dropped and the product i is kept. \square

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